There is much to understand when studying a life cycle cost comparison for paper stock pumps

CONSIDER THE TOTAL COST

It is a best practice to consider the total cost of ownership or the life cycle cost of a pump. The major components included in the cost of ownership are the initial cost, installation cost, operating cost and maintenance cost. One sub-segment of the life cycle cost is associated with the cost of sealing the pump. This white paper will identify the costs associated with sealing a pump, different sealing methods, and will compare their respective costs during the pump's life cycle.

A sealing method is required for most pumps except for magnetically driven pumps and canned rotor pumps. A sealing method must be incorporated to seal between the rotating shaft and the static stuffing box cover in order to prevent pressurized liquid from escaping.

Option 1: Packing: Packing is the original method of sealing a pump. The compressible fiber is formed to stuff the annular space between the stuffing box cover and the shaft. Packing requires lubrication and cooling to prevent excess heat generation by friction. It is normally recommended by the pump manufacturer to flush the packing with water and let it leak at a rate of 50 to 60 drops per minute. Packing requires a constant supply of clean water and periodic attention of an operator.

Options 2 and 3: Single and double mechanical seals: Mechanical seals are another method of sealing a pump. Special attention is needed to seal a paper stock pump. A regular single seal will most likely fail in a paper stock environment without a clean water flush, which provides a clean environment and lubrication between the seal faces. A carbon or Teflon thrust bushing is used at the bottom of the stuffing box.
Plan 32 requires a constant supply of pressurized water.

Flow Control Valve
Pressure Indicator

Flow Indicator (Optional)

Flush

Temperature Indicator (Optional)

Clean/Compatible External Flush Source

Clean Out Trap
Check Valve

Drain

Gland End View

Quench Optional

Plan 32 Single Seals

Figure 3: Plan 32 single seals

Courtesy of John Crane

plan 32 requirements for pressurized water.

be drastically reduced by using such bushings. One example is the SpinJet® by EnviroSeal.

The external clean liquid flush to a single seal is often referred to as the CPI Plan 7332 or simply the Flush Plan 32. A simple Plan 32 consists of a flow-regulating valve, Y-strainer and piping. It may also include optional pressure and temperature gauges, a flow indicator, a shut-off valve, and a check valve.

Double mechanical seals are also successfully used in sealing paper stock pumps. A double mechanical seal consists of two single seals mounted back to back. Pressurized barrier fluid is required for the double seal arrangement, therefore Flush Plan 54 or Plan 32 are used in conjunction with a double seal.

Flush Plan 54 includes piping and fittings to provide barrier fluid to the double mechanical seal. It may also include the combination of a flow meter, flow or pressure control valves, and a flow indicator. Flush Plan 54 is the responsibility of the customer.

Plan 53, normally the responsibility of the pump manufacturer, consists of a pressurized reservoir that usually contains a fluid such as Glycol, heat transfer fluid or vegetable oil. However, none of these fluids are allowed in paper stock applications as they can contaminate an entire batch of pulp if the inner seal fails. Using plain water as a barrier fluid might also be prohibited in geographical locations where the ambient temperature can reach below freezing.

Option 6: Dynamic seals (Dynamic seals are another means of sealing without flush water). Hydrodynamic sealing, or dynamic seals, were developed in the 1940s by the leading pump manufacturers of the day. It is a zero flush sealing method for paper stock pumps that is now preferred by many customers.

In a hydrodynamic sealing method, an expeller or repeller is installed behind the impeller inside the cavity of a modified stuffing box cover, and normally separated by a backplate. During the pump operation the pumping action of the expeller reduces the pressure at the stuffing box cover. Depending on the suction pressure, the centrifugal action of the expeller can create a slight vacuum and draws a small amount of air into the expeller cavity. As the air fills the cavity, the pumping action is reduced and equilibrium between the liquid and air phase is established.

Hydrodynamic sealing is only possible during the operation of the pump. During the idle condition, a secondary sealing method must be incorporated to prevent leakage from the static pressure of the suction head. Typical secondary sealing may include diaphragm seal, check seal, lip seal, or some rings of self-lubricating packing.

A dynamic seal eliminates the need for external flush water, but it is very limited in sealing higher suction fluid conditions.
Figure 5: Dynamic seals

Figure 6: No-flush mechanical seal vane particle ejector ring

Life Cycle Cost Calculation Methods

- Sealing costs are calculated for an end-suction pump with single seal and 3-in. sleeve OD.
- Pump operates 24 hr/day, 7 days per week.
- Life of the pump is 20 years.
- Cumulative cost or life-cycle is defined as the total expenses related to sealing the pump for the 20-year estimated life. This includes the initial cost of the sealing device, and its operational costs including power consumption and the cost of flush water.

The table below shows the life cycle cost assumptions:

<table>
<thead>
<tr>
<th>Description</th>
<th>3-inch single cartridge seal with silicon carbide faces, carbon restricting bushing and Plan 32</th>
<th>3-inch split seal with 316SS special bushing, internal grooves and Plan 32</th>
<th>Dynamic seal with split mechanical seal and silicon carbide faces, $2,848</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial cost</td>
<td>$1,675</td>
<td>$1,100</td>
<td>$5,611</td>
</tr>
<tr>
<td>Sleeve</td>
<td>$865</td>
<td></td>
<td>$1,281</td>
</tr>
<tr>
<td>Lantern ring</td>
<td>$174</td>
<td></td>
<td>$63</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$1,953</td>
<td>$1,274</td>
<td>$6,575</td>
</tr>
<tr>
<td>Replacement interval</td>
<td>2 years</td>
<td>4 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Packing—6 months</td>
<td>2 years</td>
<td>4 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Sleeve and lantern ring—1 year</td>
<td>4 years</td>
<td>4 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Replacement labor—hours</td>
<td>Sleeve and lantern ring—4 years</td>
<td>None (Replaced during major overhauls)</td>
<td>4 years</td>
</tr>
<tr>
<td>Sleve</td>
<td>.5</td>
<td>2 years</td>
<td>None (Replaced during major overhauls)</td>
</tr>
<tr>
<td>Vacuum pump, gallons per minute*</td>
<td>.5</td>
<td>2 years</td>
<td>None (Replaced during major overhauls)</td>
</tr>
<tr>
<td>Seal drag**</td>
<td>None</td>
<td>.38 HP at 1,750 rpm</td>
<td>.38 HP at 1,750 rpm</td>
</tr>
</tbody>
</table>

*U.S. Environmental Protection Agency
**Seal Drag is the additional horsepower needed to turn the shaft against the closing force of the mechanical seal faces.

Figure 7: Zero Flush Water

Back Plate
Cover
Repeller
Zero Flush Water
Slurry Seal with hard Tungsten Carbide Seal Faces
Patented Vane Particle Ejector
Springs not in fluid

Figure 8: No-flush mechanical seal vane particle ejector ring

Figure 9: Auxiliary equipment

Figure 10: Life cycle cost calculation methods

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The chart was created using lines of Openthe horizontal axis and Cumulative Cost as the vertical axis. It is important to be open minded about these cost assumptions. Costs can vary according to pump size, manufacturer and customer discount levels. In addition, the cost of water and utilities may vary from country to country, state to state and plant to plant. However, the intuitive trends revealed by this analysis provide an accurate guideline.

CONCLUSIONS

- Over a 20-year period of operation, running a single seal with thrust bearing and Plan 32 is the most expensive sealing method.
- Next in cumulative cost is for single split with SpinitTrac™ and Plan 32.
- Although packing shows low initial cost and lower operating cost, packing requires constant attention by mill personnel. It leaks continually and causes wet flooring around the pump.
- Initial cost of dynamic seal is higher. Dynamic seal also consumes higher power. But the 20-year life cycle cost is actually lower than single seal and packing. However, there are limitations on suction pressure with dynamic seal, especially when the pump is driven by VFD or at lower speed.
- TaperBore™ PLUS Seal chamber with VPE ring and John Crane 5670 cartridge Seal requires moderate initial investment, but the 20-year life cycle cost is lower than the other sealing methods.

TaperBore™ PLUS Seal chamber with VPE ring and John Crane 5670 cartridge seal advantages:
- 20-year life cycle cost is lowest among the other sealing methods.
- Lower initial investment than dynamic seal.
- High P-V (Pressure-Velocity) Limit. Can handle much higher suction pressure.
- No flash water requirement.
- No instrument air or nitrogen bottle requirement.
- Pump can be remotely located without worry.
- No freezing or cracking issues related to flash water.
- Much lower power consumption than dynamic seal, resulting in higher overall pump efficiency.
- No secondary sealing. No lip seal or elastomeric diaphragm seal.

Regardless of the variation in initial cost for each sealing method, power and water costs, and use of any flash, will increase the cost of sealing in the long run. That is the ultimate finding of this exercise.

1. SpinitTrac™ is a trademark of EnviroSeal.
2. TaperBore™ PLUS is a trademark of ITT Goulds Pumps.
3. VPE™ is a trademark of ITT Goulds Pumps.

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